Volatility Decomposition of Australian Housing Prices

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Abstract

This study examines the volatility pattern of Australian housing prices. The approach for this research was to decompose the conditional volatility of housing prices into a "permanent" component and a "transitory" component via a Component-Generalized Autoregressive Conditional Heteroskedasticity (C-GARCH) model. The results demonstrate that the shock impact on the short-run component (transitory) is much larger than the long-run component (permanent), whereas the persistence of transitory shocks is much less than permanent shocks. Moreover, both permanent and transitory volatility components have different determinants. The results provide important new insights into the volatility pattern of housing prices which has direct implications for investment in housing by owner-occupiers and investors.

Keywords: Housing prices, permanent and transitory volatilities, investment risk, Component-GARCH, Australia

1.0 INTRODUCTION

Australia has one of the highest homeownership rates at around 68% (ABS, 2009). This has traditionally reduced the pressure on the private rental market where housing investors seek a return commensurate with risk whilst providing a central role in the provision of accommodation at an affordable level. At the same time housing (either owner-occupied or investment) is an important asset in the broader economy contributing approximately 57% of the total value of Australian household assets (ABS, 2007). A recent study demonstrated housing is an effective property investment vehicle in Australia (Lee, 2008) although housing is not traditionally perceived as a broader investment asset. Given the significance of housing market, the determinants of housing prices have received extensive attention from investors, policy-makers and researchers. However, the volatility (i.e. risk) of housing prices has been largely ignored even though the global financial crisis (GFC) has increased the profile of risk and volatility of housing prices in recent years.

More importantly, many economists agree that large price swings (volatility) in housing markets have significant impacts on consumption and investment expenditures. As discussed by Xiao (2010), the boom phase of a property cycle will raise consumption and investment demand significantly. On the other hand, a sharp fall in consumption and investment spending is observed during periods of a real estate downturn which in turn damages the financial system and economic of a country. These phenomena have been observed in many Asian markets during events such as the Asian Financial Crisis, as well as in both developed and developing markets during the GFC. Therefore, it is essential to closely examine the volatility pattern of a housing market.

This study aims to provide an insight into the pattern of housing price volatility by decomposing the volatility of housing prices into a permanent component and a transitory component. Based on the argument that permanent and transitory volatilities are caused by different forces, it is reasonable to expect that factors for explaining permanent and transitory volatilities are different. Therefore, the determinants of permanent and transitory volatilities are also investigated. There are several important contributions from this study. Firstly, this study is one of the limited studies that comprehensively explore the volatility of housing prices since this research area receives relatively little attention in the literature. Secondly, this study is an innovative initial attempt to decompose the volatility of Australian housing prices. In contrast to previous studies, the volatility of Australian housing prices will be decomposed into "permanent" and "transitory" components for the first time. The results improve the level of understanding about the true volatility of the housing market, acknowledging the possibility that the conditional volatility may include two components (i.e. permanent and transitory) to describe the information transmission in the long-run and short-run volatility dynamics. Thirdly, rather than identifying driving forces of the conditional volatility of housing prices, this study provides a unique outlook into the permanent and transitory determinations of housing volatility. The results are expected to identify factors influencing the true levels of volatility in the long run.

The remainder of this paper is organised as follows. The following section reviews the related literature. Section 3 describes the data and methodology of this study. Empirical results are reported and discussed in section 4 with the final section concluding the paper. The implications of the main findings from this study are also discussed.

2.0 LITERATURE REVIEW

This section consists of three parts as follows. First, it discusses the rationale of analysing housing investment volatility, particularly the important yet often overlooked links between housing price volatility and housing affordability. The related literature in volatility modelling is reviewed in the second part. The determinants of permanent and transitory volatilities are discussed in the third part.

Links between Housing Investment Volatility and Housing Affordability

Conventional economic theory states that housing is dual purpose as both a consumer good and a producer good (API, 2007) although owner-occupiers have increasingly viewed their primary place of residence as an investment and sought to increase capital value over the long-term. For an investor in rental housing there is sustained upward pressure to increase rental levels, which can have implications on housing affordability for tenants who comprise 30% of the housing market (IBISWorld, 2007). For both owner-occupiers and investors there is an implied preference for their house prices to have low volatility where possible. At the same time governments closely monitor housing affordability and housing stress which can have indirect social and financial implications for society. For example in Australia between 2005 and 2006 on 5% of households which recently purchased did not have a mortgage, being a substantial decrease from 18% of households in 1995-96 (ABS, 2008). This equates to a higher proportion of households which may be exposed to negative equity in periods of volatile housing market, which in turn is a disincentive for private investment in the housing market by owner-occupiers as opposed to renting. It can be argued that higher perceived volatility levels and associated risk may encourage investors to alter their housing investment strategy by (a) selling their investment property and exiting the housing investment market or (b) increasing rent to cover perceived higher risk. Both scenarios have a flow-on effect for decreased housing affordability.

Housing affordability is a national research priority with many previous „attempts' to address this long-term problem (Yates, 2007). Monitoring medium to long-term house price changes coupled with the ability of the society to gain access to affordable housing have been priority areas for government (Marks and Sedgwick, 2008). There are clear issues for existing government policy which is now facing severe problems as it seeks to ease housing stress in Australia (Lending-Central, 2009). Lower housing affordability by Australian homeowners also has a flow-on effect, since additional pressure is placed on the private rental market where many households can neither afford homeownership or access public housing (Darby, 2005). At least 600,000 families and singles in the private rental market face housing stress as they pay more than 30% of their income in rent, which represents 65% of low income private renters (NationalShetler, 2009). There have been attempts to examine the impact of rental increase on housing stress levels in different Australian states (Vu, 2008) although clearly this is a widespread national problem.

(Table 1)

In comparison with other developed countries listed in an international housing affordability survey (Demographia, 2009), Australia suffered the highest housing stress with an overall median multiplier of 6.3 (Table 1). This was in direct contrast to Canada (3.1), the US (3.6), Ireland (4.7) and the UK (5.5), even though the accepted affordability standard itself is normally 3.0. Also confirming the decreased level of housing affordability in Australia was the ranking of Australian capital cities in global top 50 list of least affordable housing markets as follows: Sydney (11), Perth (19), Melbourne (22), Adelaide (35) and Brisbane (36) (DTF, 2007).

(Table 2)

When the problems associated with housing stress are converted directly into the number of households, it is evident that many Australians are directly affected. According to Mission Australia (2008) over 400,000 lower-income households are paying more than half of their income for housing. The housing stress is currently at record level (Gordon, 2008). Between 2001 and 2006 the level of housing stress in Australia has continued to increase (Table 2). Arguably many Australian households are officially in housing stress with more than a third of family income required to service the average home loan (Klan, 2006); for example NSW homeowners spend 36.4% of income on mortgage repayments with homeowners in Queensland and Tasmania at 34.9% and 33.3% respectively. In short, the volatility of housing prices has significant impact on the issues of housing affordability and housing stress. Hence, it is essential to examine the housing price volatility.

Previous Studies in Volatility Modelling

As the importance of examining the volatility of housing prices has been discussed, this section reviews previous research in volatility modelling. Earlier studies have demonstrated the importance of understanding investor perceptions towards both expected returns and volatility or risk (Asteriou and Hall, 2007). Importantly, the volatility of a financial asset has also been viewed as a key variable in many areas of finance since it also contains some important information (Bollerslev *et al.*, 1992). A seminal study, Ross (1989) concluded the volatility of an asset is directly related to the rate of information flow to the market rather than the changes of the asset. Additionally, Miller and Peng (2006) have also argued a higher level of volatility in housing prices will lead to a greater likelihood of mortgage foreclosure. Coupled with the earlier discussion about housing affordability, understanding and modelling the volatility pattern of housing prices is crucial.

Recent studies offered evidence to support the importance of housing price volatility in housing investment and policy making. These studies found the "time varying volatility" evidence in the housing markets reflected the volatility of housing prices varies over time (Dolde and Tirtiroglu, 1997; Crawford and Fratantoni, 2003; Wong *et al.*, 2006; Miles, 2008). Several studies have examined the determinants of housing price volatility; for example Miller and Peng (2006) concluded the volatility of the U.S. housing market is affected by the home appreciation rate and Gross Metropolitan Product (GMP) growth rate. Hossain and Latif (2007) presented evidence of time varying housing price volatility in the Canadian housing market. The results confirmed the GDP growth rate, house price appreciation rate and inflation are determinants of house price volatility.

These studies emphasised the conditional volatility of a housing market. However, the conditional volatility could be further decomposed into a "permanent" component and a "transitory" trend (Pagan and Schwert, 1990; Nelson, 1991). Ding and Granger (1996) highlighted that the persistence of transitory volatility (short-term) component is very weak, although its impact could be severe. The permanent component, on the other hand, has relatively smaller impact which is very persistent. As discussed by Hwang and Satchell (2000) the transitory volatility is caused by noise trading (e.g. speculation activities and trading by irrational investors), whereas the permanent (fundamental) volatility is caused by the arrival of new information. In other words, the permanent volatility of an asset is the true (fundamental) volatility of the asset. The study also revealed that transitory noise is much larger than the fundamental volatility in the U.K. stock market.

Recognising the importance of both components, Engle and Lee (1993;1999) developed a model (Component-GARCH) where the conditional volatility of an asset is decomposed into permanent and transitory components. Importantly, the studies have demonstrated that this model outperformed the traditional model (GARCH). Comparable evidence was also found by Bollerslev and Zhou (2002); Chernov *et al.* (2003); Ane (2006) and Guo and Nelly (2008). More recently, Adrian and Rosenberg (2008) also found that both components captured different sets of information. In the real estate literature, Bond and Hwang (2003) have exhibited a common (fundamental) component of volatility shared by direct properties and securitised real estate. Their results also confirmed the permanent volatility of an asset is the true volatility of the asset. The strong evidence of long-term memory volatility is also observed in most international real estate markets by Liow *et al.* (2009). Recently, Liow and Ibrahim (2010) demonstrated the existence of significant "permanent" and "transitory" components in the volatilities of international securitised real estate markets. Furthermore, significant differences between the "permanent" and "transitory" volatility movements at the international level are also evident.

Although these studies have enriched the understanding of volatility patterns across markets in the real estate context, a detailed study has not been conducted on the permanent and transitory volatilities of housing. The only exception is Fraser *et al.* (2010). It should be noted that housing differs fundamentally from securitised real estate in at least two ways. First, housing is not listed centrally on any stock exchange; therefore it is an illiquid asset. Second, housing is not only an effective property investment vehicle, but has a second role as a consumer good providing shelter (API, 2007). As a result, the findings from previous studies in securitised real estate would not necessarily be generalised into a housing market. However, no empirical study to-date has been devoted in this direction in the literature. Therefore it is clear that numerous issues surrounding the volatility of housing prices have not yet been examined or adequately addressed in the existing literature.

Drivers of Permanent and Transitory Volatilities in Housing Prices

Given that the conditional volatility of housing prices could be decomposed into permanent and transitory components, the driving forces of both components should be identified. However relatively little emphasis has been placed on the permanent and transitory components in housing prices. One exception is a study by Fraser *et al.* (2010) which used a structural VAR model to investigate the responses of house prices to permanent and transitory shocks in real income. They found that real house prices are sensitive to permanent shocks in real income in the UK, the US and New Zealand. However, no similar evidence is found for transitory shock in the US.

Although there is little study on the determinants of permanent and transitory volatilities in housing prices, there are some indirect evidence in the literature of housing price bubbles and fundamentals[1]. The transitory volatility of an asset is driven by non-fundamental speculative phenomenon such as speculation activities and irrational trading partly influenced by perception. Thus, factors that are significant for speculative behaviour in the housing market

[1] Fundamental housing prices are defined as house prices that can be justified by fundamental factors. See Stiglitz (1990) and Stevenson (2008).

could be strongly linked to the transitory volatility of housing price. On the other hand, the permanent volatility of housing prices is caused by the availability of new information. It is correlated to the fundamental of the housing market. Therefore, it is reasonable to expect that variables relate to housing market fundamentals are relevant to the permanent volatility of housing prices.

Ito and Iwaisako (1995) found the availability of lending funds has a strong link with the Korean and Japanese housing bubbles in the late 1980s and early 1990s. Hendershott (2000) found that bubbles could be connected to a lengthy lag in supply. More specifically, restrictions in supply could be key factors linked to speculative bubbles in the property market. Bourassa *et al.* (2001) employed an employment variable to study speculative behaviour in the housing market. Case and Shiller (1989) and Abarahams and Hendershott (1996) concluded that lagged appreciation term represents speculative pressures in the housing market. More recently, Garcia et al. (2007) also used this variable to account for housing bubbles in the Spanish housing market.

Numerous studies have attempted to model housing market fundamentals. Kim and Lee (2000) found that land prices are co-integrated with GDP in the long run. However, no similar relationships are found in the short run. Meese and Wallace (2003) demonstrated that employment and income are the critical determinants of housing prices in Paris over the long run. Interestingly, their results also showed the level of interest rates and cost of capital are less likely correlated with the Parisian real estate market in the long run. Tu (2004) found the real GDP and housing stocks are significantly related to the Singapore private housing market in the long run. In Australia, an early study by Maher (1994) found that housing price change could be attributed to real interest costs, inflation, incomes and a number of institutional factors such as demographic shifts. More recently, population, income, housing stocks and interest rates have been used by Stevenson (2008) in examining housing market fundamentals. Overall, these studies identified certain variables, namely housing supply, lending rate, GDP, incomes, inflation rate and population, which will be used in this study in order to identify permanent and transitory driving forces.

3.0 DATA AND METHODOLOGY

Data

Quarterly data of eight capital cities for the period Q4:1987-Q3:2009, for a total of 88 observations were obtained from the Australian Bureau of Statistics (ABS). These eight capital cities, namely Sydney, Melbourne, Brisbane, Perth, Adelaide, Hobart, Canberra and Darwin, represent every state and territory in Australia are as well as the Australian housing market in aggregate.

(Insert Figures 1 and 2)

Figure 1 plots the relative performance of the ABS Australian housing prices index over the period 1987 to 2009, rebased to an index figure of 100 at the start of the sample. Casual inspection of the figure exhibits a decidedly upward trend over the study period. Another interesting observation is the index was highly variable in the 1980s but it grew smoothly throughout 1990s. Thereafter, it became highly variable again. This trend is also clearly documented in Figure 2. All of these suggest that the housing series is called conditionally heteroskedastic in the light of the unconditional variance is constant, but there are periods in which the variance is relatively high. Therefore, modelling the volatility of the housing market is essential[2]. Table 3 presents summary statistics for these markets. Returns are calculated by the first difference of the natural logarithm of the quarterly indices.

(Table 3)

The results show that all average returns were positive over the period. Perth recorded the highest quarterly return (2.2%), while Adelaide had the lowest appreciation rate over this period. The quarterly standard deviations range from 2.3% for Australia to 3.2% for Perth. Interestingly, the largest Australian housing markets of Sydney and Melbourne reveal higher unconditional volatility, compared to smaller housing markets of Adelaide, Canberra and Darwin. This suggests larger cities are more volatile than smaller cities. All series are positively skewed except Adelaide. Excess kurtosis (kurtosis value more than 3) is also evident in all series with the only exception being Canberra. Note the results imply that these series are not normally distributed where the Jarque-Bera analysis further reinforced this observation. The normality distribution assumptions have been rejected for all series, with minor exceptions of two capital cities (Canberra and Adelaide).

(Table 4)

Table 4 shows the correlation matrix of these markets. The Australian housing series is strongly correlated with housing markets in the two largest capital cities (Sydney and Melbourne), signifying that the Australian housing market is strongly influenced by the

[2] The formal testing is necessary to substantiate any first impressions.

housing markets in Sydney and Melbourne. Moreover, the ABS Australian housing prices index is a weighted-index and the weights of Sydney and Melbourne contribute more than 60% of the total index. Hence, it is not surprisingly to find that the Australian housing market is strongly correlated with those two largest cities in Australia. Additionally, low correlation coefficients are observed between Darwin and other capital cities, suggesting that diversification benefits could be obtained by including Darwin residential properties within a housing portfolio.

Methodology

Unit root tests were first performed to examine the stationarity of these time series. The results show that the series are stationary. Next, this study follows the framework of Engle and Lee (1993, 1999) and Liow and Ibrahim (2010) to analyze the volatility pattern of housing prices. The process begins by estimating the ARCH effects for each series. Ljung-Box test and LM test for ARCH effects were conducted to detect the volatility clustering effect in each series. Ljung-box tests were performed for the standardised residuals and their squared values. As noted by Miles (2008), volatility modelling is only required for the series that exhibit the volatility clustering effect. Therefore, if the volatility clustering effect is found in a series, a Component-GARCH (C-GARCH) model will be performed for the given series.

The C-GARCH model was developed by Engle and Lee (1993, 1999). The model decomposes the volatility of a series into two components which one component captures the short run innovation (transitory volatility component) and the other captures the long-run impact of an innovation (permanent volatility component). As highlighted by Engle and Lee

(1993, 1999), the C-GARCH model has enriched the volatility modelling by decomposing the volatility of a series into the long run (permanent) and short run (transitory) components. The model can be estimated as follows:

Mean Equation:

$$R_t = a_0 + a_1 R_{t-1} + a_2 R_{t-2} + a_3 R_{t-3} + \varepsilon_t \qquad (1)$$

Variance Equations:

$$\sigma_t^2 - q_t = \alpha(\varepsilon_{t-1}^2 - q_{t-1}) + \beta\left(\sigma_{t-1}^2 - q_{t-1}\right) \qquad (2)$$

$$q_t = \omega + \rho\left(q_{t-1} - \omega\right) + \phi\left(\varepsilon_{t-1}^2 - \sigma_{t-1}^2\right) \qquad (3)$$

where q_t is the long-run volatility (trend) component and the difference between the conditional variance and its trend, $\sigma_{t-1}^2 - q_{t-1}$, is known as the transitory volatility component. The transitory component converges to 0 with powers of $\alpha + \beta$. The conditional mean equations consist on either AR(1), AR(2) or AR(3). Akaike Information criterion was employed to select the best model specification.

The volatility linkages between these components and economic variables are investigated by including the variables individually either in the transitory or permanent component as follows:

Mean Equation:

$$R_t = a_0 + a_1 R_{t-1} + a_2 R_{t-2} + a_3 R_{t-3} + a_4 Eco_{i,t-1} + \varepsilon_t \qquad (4)$$

Variance Equations:

$$\sigma_t^2 - q_t = \alpha(\varepsilon_{t-1}^2 - q_{t-1}) + \beta\left(\sigma_{t-1}^2 - q_{t-1}\right) + \delta Eco_{i,t-1} \tag{5}$$

$$q_t = \omega + \rho\left(q_{t-1} - \omega\right) + \phi\left(\varepsilon_{t-1}^2 - \sigma_{t-1}^2\right) + \gamma Eco_{i,t-1} \tag{6}$$

where $ECO_{i,t-1}$ is the macro-economic variable. The considered variables in this study are real GDP, unemployment rate, income, inflation rate, population growth rate, lending rate and housing building approval rate. The data of these variables were obtained from the ABS. The lagged housing prices are also included in the transitory component modelling.

4.0 RESULTS AND DISCUSSION

ARCH Effects

Although Figures 1 and 2 have demonstrated some indirect evidence to support the presence of volatility clustering effect in the housing market, its presence in the Australian housing series was also formally examined by using the Ljung Box test and Engle (1982) ARCH test. The results are depicted in Table 5.

(Table 5)

As Table 5 illustrates, strong ARCH effects are found in Australia, Sydney, Perth and Hobart housing series in which Q(3), $Q^2(3)$ and ARCH(3) are statistically significant at the 5% level. The only exception is Perth with an insignificant Q-statistic. Additionally, the volatility clustering effect is also evident in the series of Melbourne and Brisbane, although the coefficients are only significant statistically at 10%. Results here suggest that the volatilities of these series are varying over time and certain periods of tranquillity followed by others of extremely high variability. Therefore, the standard risk measure (unconditional volatility) could underestimate the actual uncertainty level of the series, reflecting that it is vital for property analysts and policy makers to model the volatility of housing prices in the light of it contains some essential information that should be analysed. In other words, an analysis will be conducted to model the volatility series of the Australian, Sydney, Melbourne, Brisbane, Perth and Hobart housing markets. Coincidentally, the volatility clustering effect is not found in the series of Adelaide, Darwin and Canberra. As depicted in Table 3, these markets exhibit the lowest risk level, implying that the presence of ARCH effect is more likely associated with the volatile markets.

In summary, modelling the volatility of housing prices is a vital step to properly managing risk in Australian housing investment. As a result, a volatility decomposition analysis is carried out for the series that exhibit the volatility clustering effect.

Volatility Decomposition

Having established which housing series reveals the ARCH effects, a C-GARCH model was utilised to decompose the conditional variance of the series into a permanent component and a transitory component. The results are presented in Table 6.

(Table 6)

There are several important observations from Table 6. Firstly, the shock impacts on the long-run component that are represented by ρ parameters, are above 0.9 for all housing markets except Sydney and Brisbane. The results suggest that the permanent volatility component is very persistent and converges slowly to the steady state. On the other hand, the persistence level of the transitory component that is denoted by the sum of $\alpha+\beta$, is much weaker. The magnitudes ($\alpha+\beta$) of all housing markets are smaller than their corresponding ρ values, indicating that the persistency of the permanent shock is much greater than the transitory shock. Furthermore, the half-live of the permanent response to a shock is the longest in Melbourne (11.6 quarterly)[3] and the shortest (2.4 quarters) in Sydney. In contrast, shocks to the transitory component last for a far shorter time in which the transitory half-lives range from 1.7 quarters (Brisbane) to 4.6 quarters (Melbourne)[4]. These results indicate that divergences of the conditional variance and its trend (permanent) are temporary for all housing markets. The results are also consistent with Engle and Lee (1999) for the stock market and Liow and Ibrahim (2010) for the international securitised real estate markets, indicating that the overall duration for the permanent component is much longer than for the transitory component.

Nevertheless, the magnitudes of the transitory volatility component (α) are larger than the permanent volatility component (ϕ), suggesting that the shock impact on the transitory volatility component is greater than the permanent volatility. The absolute values for factor of proportionality (α/ϕ), on average, is 1.39, reflecting that the average shock effects on the transitory and permanent components differ by a factor of approximately 1.4 on average. The

[3] The past shock persistency of the volatility can be measured by the half-live by $\log(0.5)/\log(\rho)$ in the permanent component and $\log(0.5)/\log(\alpha+\beta)$ in the transitory component.

[4] The transitory half-live of Perth is unavailable due to the negative figure. The negative figures also found by Liow and Ibrahim (2010) for the Australian securitised real estate market.

results are consistent with the evidence presented above on half-live decay to shocks for both permanent and transitory volatilities. The finding is intuitively appealing as the transitory volatility component captures the temporary volatility of housing prices that is caused by noise trading and speculative investments. Therefore, these transactions are very sensitive to the shocks. In contrast, the impact of this new information is less severe on the permanent volatility component in the light of it only captures the fundamental of the housing market. The results also provide some indirect support to the findings in previous studies such as Liow and Ibrahim (2010) and Engle and Lee (1999) in the securitised real estate and stock markets.

(Table 7)

Table 7 reveals the diagnostic tests for these C-GARCH models. In general, all models are well specified. The insignificant statistics of Q(6), Q(12), $Q^2(6)$, $Q^2(12)$, ARCH(6) and ARCH(12) are observed for all models, suggesting the success of the component-GARCH models in capturing the typical serial correlations. The only exception is the Q-statistics of the Melbourne C-GARCH model. However, the Q^2 and ARCH statistics for Melbourne did not offer a similar conclusion since these statistics are statistically insignificant. More importantly, there is no evidence to support that the presence of ARCH effects in any series. In short, these models are correctly specified in order to describe the permanent and transitory volatility patterns of Australian housing prices.

Overall, the volatility of housing prices could be decomposed into two different components, which are the transitory volatility and permanent volatility components. Importantly, the impact of an innovation (i.e. new information) would be severe on the transitory volatility component, although the impact will disappear shortly. In contrast, the influence of the new information is minor on the permanent volatility component, while the impact is very persistent. The results have some important caveats to policy makers in which they should aware the differences. Importantly, they should examine the potential impact of their policies to the housing market on the long-run and short-run individually.

Permanent Volatility Spillover

Recognising the presence of two significant volatility components for the housing markets, we should consider both short-run and long-run models with different sets of explanatory variables attached to the 2 separate models of volatility. Since both components capture different sets of information and reveal different degrees of persistence, it is reasonable to expect the determinants of both volatility components could be different. This section examines the linkages between the permanent volatility of housing prices and the growth rate of real GDP, real income, population, unemployment rate, lending rate, inflation rate and building approval for each market. The results are reported in Table 8.[5]

(Table 8)

The coefficients of inflation rate are statistically significant at the 5% level in all markets with minor exceptions (Melbourne at the 10% level and insignificant for the Perth housing market), indicating that there is a strong association between the permanent volatility of housing prices and inflation rate. This could be attributed to the inflation-hedging effectiveness of residential properties. Fama and Schwert (1977) and Hamelink and Hoesli

[5] The full results are available from the authors.

(1996) have demonstrated that housing is an effective hedging asset to inflation, signifying that households could protect the real purchasing power of their investments. More importantly, Maher (1994) has demonstrated that the growth expectation towards housing is a critical driver of the housing demand. In other words, the growth of inflation may make housing as a desirable investment asset, thereby pushing up the movements of housing prices. It is, therefore, reasonable to find that the movements in inflation rate will be transmitted to the permanent volatility of housing prices. However, the inflation growth rates have a negative impact on the permanent volatilities of Sydney, Brisbane and Hobart. One of the possible explanations could be investors tend to hold their properties during a high inflationary environment and therefore reducing the level of volatility in these markets. The results also imply the segmentation of Australian housing markets at sub-national level. The segmentation evidence in the Australian housing market has also been demonstrated by Tu (2000).

There is also a strong connection between real GDP growth rate and the permanent volatility of housing prices. The coefficients of real GDP are statistically significant at the 5% level in the Australia, Sydney, Brisbane and Perth housing markets. This suggests that the real GDP growth rates impound important information for the housing market. The real GDP growth rate is an important indicator of the overall economics' output of a country. It measures the prosperity of the economy. Intuitively, the growth of the economy will increase the demand of consumption, including housing. Therefore, information transfer between real GDP and housing markets is sensible. Again, the disparities at sub-national level are also evident. Specifically, the coefficient of real GDP is negative in Brisbane, suggesting that national housing policy should consider the sub-national disparities.

Nevertheless, there is little evidence to support the hypotheses of strong volatility spillover from other variables to the permanent volatility of housing prices. Specifically, income growth rates are only strongly linked to the permanent volatility components of the Sydney and Perth housing markets, whereas no similar evidence is available for other housing markets. Undoubtedly, income growth is one of the most vital components of housing affordability. It is quite surprising to find little relation between the permanent volatility component and income growth. The insignificance of income variable probably could be attributed to its low growth rate in recent years. The rise of housing prices was also almost double higher than the rate of wage growth over this study period. In turn, its role has been offset by other factors such as inflation growth rate and real GDP.

Comparable insignificant results are also found for population growth rate, lending rate, unemployment rate and building approval rate. These variables exhibit little relations with the permanent volatilities of residential properties, suggesting that these factors are not the determinants of the true volatility of housing prices. Notably, lending rates are statistically insignificant in explaining the permanent volatility of any housing market, suggesting that the changes in the monetary policy does little to solve the real problem of the housing market that is captured by the permanent volatility.

To sum up, the permanent volatility was largely driven by the inflation rate and real GDP growth rate. In other words, the true volatility of the housing market has a strong response to these factors. Thus policy makers should incorporate this finding in their policies since the permanent volatility is the actual volatility of the Australian housing market.

Transitory Volatility Spillover

To shed more lights on the differences between permanent and transitory volatility components, this section examines the determinants of the transitory volatilities of housing prices. The results are presented in Table 9.

(Table 9)

The immediate observation from Table 9 is the Australian housing markets are sensitive to transitory shocks in the population growth rate. More specifically, the coefficients of population are statistically significant for all models with the only exception being the Sydney housing market. The results are intuitively appealing in which the growth of population will increase the demand of housing. However the supply of housing is very inelastic since the supply of new houses cannot respond instantaneously to a jump in demand. As discussed by Grimes and Aitken (2010), an upward demand shift will translate into a jump in house prices in order to equate short term demand and supply, thereby pushing the volatility of the housing market, particularly the short-term volatility. As a result, the population growth rate is an important determinant of housing prices volatility in the short run. Interestingly, the impact of population is negative on the transitory volatility of the Hobart housing market. This could be attributed to the low population in this city. It should be noted that the population of Hobart (212,019 people) is relatively small compared to other cities such as Sydney (4.5 million), Melbourne (4 million) and Brisbane (2 million) (ABS, 2010). Therefore, a sustained population growth is desired in reducing the transitory volatility of this housing market.

Another important determinant of the transitory volatility component is the lagged growth rate of housing prices. The coefficient of this variable is positive and statistically significant in all markets, except the Hobart housing market. This has provided some indirect support for the findings of previous studies in which the lagged housing prices would capture the bubble in a housing market. In addition, the growth rate of real GDP also shows strong volatility spillover to the transitory volatility of housing prices. As discussed earlier, the growth of the economic in a country would increase the product consumptions, including residential properties. Thus the strong transitory volatility linkages between real GDP and housing could also be explained in the similar fashion. Importantly, the results show that the real GDP growth rate is not only a driver of the permanent volatility component, but also the transitory volatility component.

Comparing to the results of the permanent volatility spillover, inflation rate shows a lesser extent of linkages with the transitory volatility of housing prices. This variable is only statistically significant at 5% for the Sydney, Brisbane and Perth housing markets. The long investment horizon of housing could be an acceptable explanation since property investments are traditionally considered as a long term investment. Therefore, the information that contains in the inflation rate could be largely captured by the long run component (permanent volatility). Nonetheless, the information is less critical for the transitory volatility which is normally caused by non-fundamental activities. Moreover, the inflation rate variable also has mixed flow-over effects on the transitory volatilities in different cities, suggesting that the segmentation of Australian housing markets at sub-national level.

Interestingly there was no defined relationship observed between interest rates and the long run volatility of housing price, although some volatility spillover effect from interest rates to the transitory volatility was evident. Interest rates are considered as key macroeconomic policy instruments. Most importantly, interest rates had a powerful influence on aggregate demand in the economy (RBA, 2010). Hence the changes in interest rates have immediately impacts on the behaviour of investors, households and businesses. In turn, speculative housing investments could be significantly reduced by a tight monetary policy. Thus, it is sensible to find that lending rates are strongly linked to the temporary component. Conversely, these changes are unimportant for the fundamental volatility of housing price. Importantly, policy makers should recognise this point in which the change in their monetary policy will be quickly assimilated to the transitory volatility, whereas its impact on the permanent volatility is insignificant.

Even though income, unemployment rate and building approval exhibit some linkages with the transitory volatility of housing prices, the results are less conclusive. The variables are only significant for the transitory volatility of certain sub-markets. In other words, no evidence of strong linkages between these variables and the volatility of housing prices in the short-run has been established. As discussed earlier, the negligible role of income variable is attributed to the low income growth rate. Over this study period, the growth rate of housing price was considerably higher than the income growth rate. Similarly to building approvals, the growth rate of building approval was marginal over this period. Therefore it is not too surprisingly that the variable only contains little information of the transitory volatility component. Interestingly housing markets in Brisbane and Perth react quickly to temporary shocks in housing building approvals. Coincidentally, higher building approval rates are also found in these capital cities, indicating that the significance of this variable is somewhat related to its growth rate.

Overall the population growth rate, lagged housing prices, real GDP growth rate and lending rates appeared as important determinants of the transitory volatility component. Comparing to the determinants of the permanent component, the transitory volatility component exhibits different determinations, confirming the hypothesis of both volatilities capture different sets of information that have been discussed by Adrian and Rosenberg (2008).

Robustness Checks

Several robustness checks were also performed. Firstly, the baselines results were re-examined by real returns, although the inflation rate in Australia was stable over this period. No significant variation was found by comparing the results based on real returns to the baseline results in which the volatility of real house prices could be decomposed into a permanent component and a transitory component. The permanent volatility is more persistent than the transitory component, although its impact is marginal. Different determinations are also found for different volatility components. Thus our results are robust to real and nominal returns.

Another important issue is the ABS modified its house price index methodology in 2005. Although the suggested method of re-referencing and linking price indices by the ABS was followed in this study, in order to examine the robustness of our results another dataset from the Real Estate Institute of Australia was also employed. The results show the permanent volatility of housing is very persistent with reference to the ρ parameters for all markets are statistically significant at the 1% level. Besides, the persistency level of the transitory shocks is less than the permanent shocks. The results also confirmed the shock impact on the transitory volatility component (α) is greater than the permanent component (ϕ). In other words, the preceding results in the Australian housing market based on the dataset from the ABS are robust.

5.0 CONCLUSIONS AND IMPLICATIONS

The volatility of housing prices has received increasing attention in recent years. Much of it has concentrated on the volatility linkages of housing prices and macroeconomic variables. However this study focused on a related issue, the volatility decomposition of housing prices. This is a critical issue although has not been closely examined in previous housing studies. Therefore this study examined the volatility patterns of Australian housing prices from a different contextual setting than has previously been attempted in which the volatility of housing prices was decomposed into a permanent component and a transitory component.

These are several important findings from this study. Firstly, the volatility clustering effect was found in most housing series, suggesting that the volatility series of these markets convey some important information that should be analysed. Secondly, the volatility of housing prices can be decomposed into permanent and transitory components. Importantly, there is clear pattern in the differences between the permanent and transitory volatilities. The shock impact on the transitory volatility is much greater than the permanent volatility, although the impact is temporary in which it only lasts for around 1.7 quarters to 4.6 quarters. Thirdly, both volatilities capture different sets of information and have different determinants. Specifically, real GDP and inflation rate reveal strong linkages with the permanent volatility component of housing prices, whereas population, lagged housing prices, real GDP and lending rate are the major determinants of transitory volatility. These findings imply that housing markets will react differently to the shocks of these macroeconomics variables. The findings have provided new insights into the volatility pattern of housing prices.

These findings have some important practical implications to policy makers, property analysts and housing investors. The presence of volatility clustering effect indicates the volatility of home prices is time varying and is not constant over time. In other words, portfolio managers and housing investors should adjust their portfolio management practice in response to the traditional risk measure of unconditional variance could underestimate the actual volatility dynamics of housing prices. Besides, the volatility decomposition of housing prices into the transitory and permanent components suggests that policy makers and urban analysts should have a closer look into the volatility of the housing market. They should analyses the permanent and transitory volatilities of housing price individually. An enhanced understanding the differential volatility dynamics is likely to improve their understanding of the volatility dynamics.

Moreover, the finding of different determinants of permanent and transitory volatilities reflects the permanent and transitory volatilities of housing prices will react differently to the economic activities. It is a critical feature which should be recognised and considered in the macroeconomic policy decisions and implementations. By recognising this feature, policy makers will identify the true factors that affecting the fundamental of the housing market, leading to improvements in formulating an effective housing policy and therefore reducing the level of volatility in the housing market. For instance, the change in monetary policies by the Reserve Bank of Australia has immediately impacts on the transitory volatility. However, its impact on the permanent volatility is negligible. On the other hand, the growth rates of inflation and GDP are major factors to influence the true volatility of the housing market in the long run. In addition, the findings are also important for housing investors. They would able to improve their strategic and tactical asset allocations since their have to determine the proper weights of long term assets in their strategic portfolio allocations and constantly adjust their assets mix for their tactical allocations.

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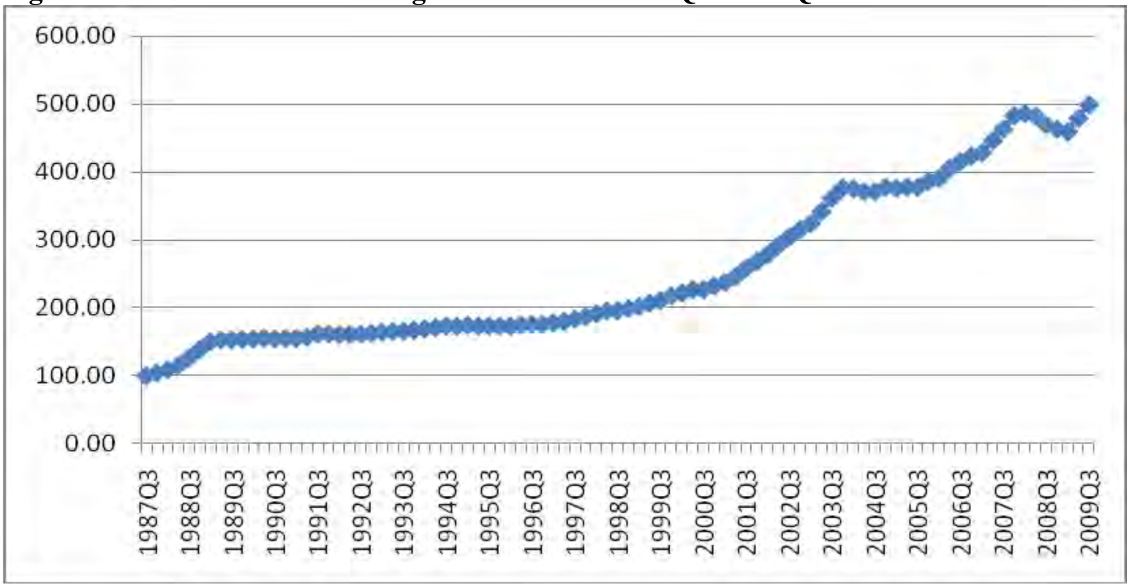
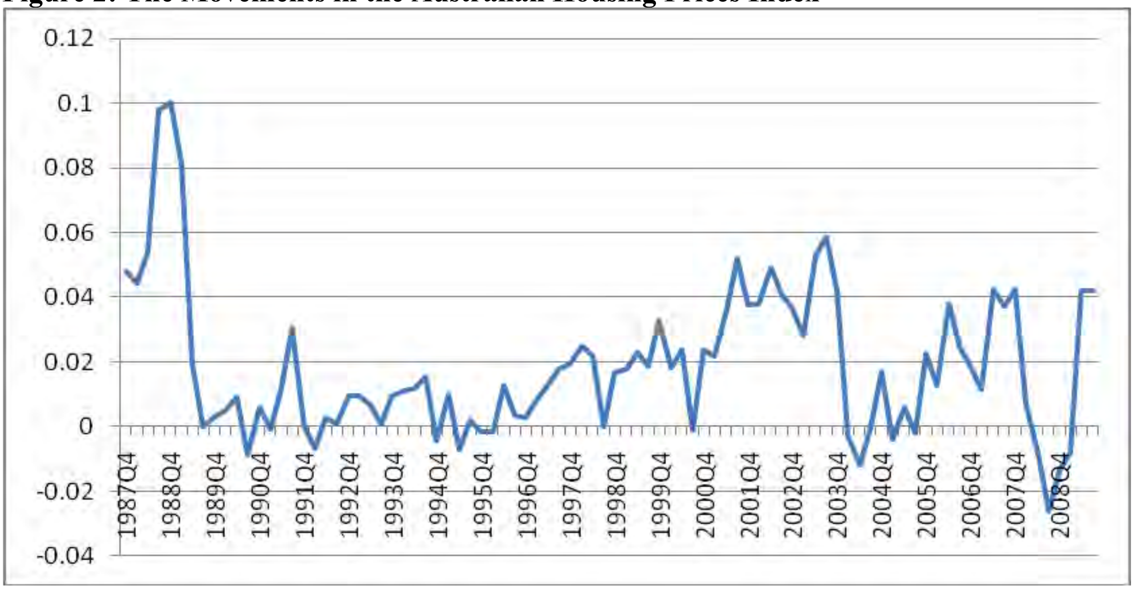
Figure 1: The Australian Housing Prices Index: 1987:Q3-2009:Q3



Source: ABS (2010). The index was re-based to an index figure of 100 at the start of the sample.

Figure 2: The Movements in the Australian Housing Prices Index



Source: ABS (2010)

Table 1: Housing Stress Multipliers

	Affordable (3.0 & under)	Moderately Unaffordable (3.1-4.0)	Seriously Unaffordable (4.1-5.0)	Severely Unaffordable (5.1 & over)	Total	Median
Australia	0	0	3	24	27	6
Canada	1	15	5	4	34	3.5
Ireland	0	0	2	3	5	5.4
NZ	0	0	1	7	8	5.7
UK	0	0	6	10	16	5.2
US	7	59	23	16	175	3.2
Total	8	74	40	64	265	

Source: Demographia (2009)

Table 2: Housing Stress for Households and Individuals (%)

	2001	2002	2003	2004	2005	2006
All						
Household	10.6	10.9	11.2	11.5	11.5	12.3
Individual	8.7	9	9	9.4	9.3	9.9
Owners						
Household	5.3	5.4	5.6	6.1	6.4	8.1
Individual	4.8	4.8	5	5.5	5.9	7.2
Renters						
Household	23.9	24.4	25.3	24.8	24.3	23.1
Individual	20.1	21.6	21	21.4	19.9	18.4

Source: Marks and Sedgwick (2008)

Table 3: Summary Statistics

Cities	Mean	Max.	Min.	Standard Deviation	Skewness	Kurtosis	Jarque-Bera
Australia	1.870	10.012	-2.617	2.305	1.183	4.970	34.733***
Sydney	1.768	14.150	-3.744	3.059	1.409	6.069	63.669***
Melbourne	1.999	11.654	-5.277	3.176	0.474	3.753	5.371*
Brisbane	2.177	12.274	-3.833	2.771	1.009	4.320	21.315***
Adelaide	1.611	7.182	-7.045	2.469	-0.127	3.940	3.476
Perth	2.153	14.440	-2.703	3.228	1.330	5.338	45.980***
Hobart	1.764	14.680	-4.218	2.922	1.867	8.739	171.89***
Darwin	1.950	8.458	-9.433	2.558	-0.834	6.365	51.710***
Canberra	1.740	8.566	-3.473	2.447	0.501	2.930	3.696

Notes: The first two-moment (mean and standard deviations) are expressed in the percentage form. The skewness and kurtosis statistics have a value of 0 for a normal distribution. These statistics and Jarque-Bera statistics give a preliminary indication of the normality of these assets. The count for all markets is 88.

Table 4: Correlation Matrices: All Markets

Cities	Australia	Sydney	Melbourne	Brisbane	Adelaide	Perth	Hobart	Darwin	Canberra
Australia	1.000								
Sydney	0.894	1.000							
Melbourne	0.811	0.572	1.000						
Brisbane	0.679	0.514	0.400	1.000					
Adelaide	0.422	0.287	0.255	0.532	1.000				
Perth	0.593	0.420	0.394	0.358	0.125	1.000			
Hobart	0.414	0.237	0.230	0.633	0.493	0.335	1.000		
Darwin	-0.034	-0.152	-0.080	0.089	0.089	0.184	0.193	1.000	
Canberra	0.667	0.531	0.449	0.731	0.441	0.353	0.547	-0.056	1.000

Table 5: ARCH Tests

Cities	Q(3)	$Q^2(3)$	ARCH(3)
Australia (ρ-value)	12.025 (0.007)***	10.961 (0.012)**	18.930 (0.000)***
Sydney (ρ-value)	10.695 (0.013)**	7.931 (0.047)**	12.774 (0.005)***
Melbourne (ρ-value)	6.463 (0.091)*	7.321 (0.062)*	7.508 (0.057)*
Brisbane (ρ-value)	0.842 (0.839)	7.728 (0.052)*	7.053 (0.070)*
Perth (ρ-value)	0.681 (0.878)	21.834 (0.000)***	19.814 (0.000)***
Adelaide (ρ-value)	2.904 (0.407)	0.518 (0.915)	0.445 (0.931)
Hobart (ρ-value)	17.432 (0.001)***	11.069 (0.011)**	10.324 (0.016)**
Darwin (ρ-value)	3.143 (0.370)	0.232 (0.972)	1.319 (0.725)
Canberra (ρ-value)	2.126 (0.547)	1.284 (0.733)	1.195 (0.754)

Notes: This table reports the estimated results from the Ljung-Box and Engle (1982) LM tests. Q(3) and $Q^2(3)$ are the Ljung-Box tests for the standardised residuals and their squared values respectively. ARCH(3) exhibits the LM test up to 3-order. * denotes significance at the 10% level; ** represents significance at the 5% level and *** denotes significance at the 1% level

Table 6: C-GARCH(1,1) Model

Cities	Australia	Sydney	Melbourne	Brisbane	Perth	Hobart
a_0	0.004 (4.285)***	0.007 (4.014)***	0.011 (4.498)***	0.004 (2.131)***	0.006 (3.147)***	0.009 (4.668)***
a_1	0.671 (11.090)***	0.611 (10.282)***	0.308 (3.667)***	0.734 (10.215)***	0.571 (9.674)***	-0.064 (-1.210)
a_2		0.253 (3.884)***			0.128 (2.144)**	0.380 (14.865)***
a_3		-0.331 (-7.288)***				
ω	0.000 (843.398)***	0.000 (85.969)***	0.001 (1.203)	0.001 (1.843)*	0.001 (0.554)	0.001 (305.713)***
ρ	0.917 (18.587)***	0.746 (19.051)***	0.954 (7.171)***	0.752 (1.020)	0.942 (8.682)***	0.940 (16.581)***
ϕ	0.351 (1.125)	-1.957 (-0.166)	-0.335 (-0.412)	1.598 (0.960)	0.476 (6.422)***	-0.280 (-0.432)
α	-0.459 (-1.654)*	1.821 (0.155)	0.400 (0.495)	-1.423 (-0.045)	-0.346 (-4.770)***	0.923 (1.051)
β	1.202 (3.132)***	-1.104 (-0.096)	0.460 (0.776)	2.093 (0.064)	-0.561 (-7.665)***	-0.181 (-0.273)
Log-likelihood	248.543	219.089	193.711	225.690	222.460	220.779

Notes: This table reports estimated coefficients for mean and variance equations of C-GARCH (1,1) model. The model is estimated by
Mean Equation:

$$R_t = a_0 + a_1 R_{t-1} + a_2 R_{t-2} + a_3 R_{t-3} + \varepsilon_t$$

Variance Equations:

$$\sigma_t^2 - q_t = \alpha(\varepsilon_{t-1}^2 - q_{t-1}) + \beta\left(\sigma_{t-1}^2 - q_{t-1}\right)$$

$$q_t = \omega + \rho\left(q_{t-1} - \omega\right) + \phi\left(\varepsilon_{t-1}^2 - \sigma_{t-1}^2\right)$$

Bollerslev-Wooldrige robust standard error and covariance are employed. *, **, *** denotes significance at the 10%, 5% and 1% level respectively.

Table 7: Specification Tests for the C-GARCH Model

Cities	**Q(6)**	**Q^2(6)**	**Q(12)**	**Q^2(12)**	**ARCH(6)**	**ARCH(12)**
Australia	10.759 (0.096)*	6.266 (0.394)	12.415 (0.413)	10.006 (0.615)	6.779 (0.342)	11.181 (0.514)
Sydney	7.892 (0.246)	5.816 (0.444)	10.522 (0.570)	7.929 (0.791)	3.608 (0.730)	7.275 (0.839)
Melbourne	16.796 (0.010)**	2.175 (0.903)	36.405 (0.000)***	4.340 (0.976)	2.690 (0.847)	4.663 (0.968)
Brisbane	2.968 (0.813)	4.450 (0.616)	4.732 (0.966)	8.035 (0.782)	3.582 (0.733)	7.439 (0.827)
Perth	1.832 (0.934)	6.431 (0.377)	8.272 (0.764)	10.140 (0.604)	5.375 (0.497)	8.307 (0.761)
Hobart	4.150 (0.656)	2.455 (0.874)	7.585 (0.817)	5.550 (0.937)	2.373 (0.882)	6.068 (0.913)

Q(6), Q(12), Q^2(6) and Q^2(12) are the Ljung-Box tests for the standardised residuals and their squared values respectively. The ARCH(*p*) exhibits the LM test up to *p*-order. * denotes significance at the 10% level; ** represents significance at the 5% level and *** denotes significance at the 1% level

Table 8: "Permanent" Volatility Spillover

Cities	Australia	Sydney	Melbourne	Brisbane	Perth	Hobart
Real GDP	0.005 (3.195)***	0.007 (5.789)***	-0.018 (-1.330)	0.006 (2.922)***	-0.002 (-2.084)**	-0.004 (-1.253)
Income	0.000 (0.178)	0.009 (4.268)***	-0.012 (-1.594)	-0.000 (-0.161)	-0.010 (-4.173)***	0.006 (1.219)
Population	0.033 (0.056)*	0.012 (0.258)	0.031 (1.965)**	0.001 (0.024)	0.023 (1.065)	0.828 (3.278)***
Unemployment	-0.000 (-1.466)	-0.000 (-0.390)	-0.000 (-0.294)	0.000 (0.242)	-0.004 (-3.164)***	0.001 (2.694)***
Lending rate	0.000 (0.388)	0.000 (1.205)	0.002 (1.530)	0.000 (0.074)	0.000 (0.393)	-0.000 (-0.754)
Inflation	0.007 (2.546)**	-0.004 (-2.697)***	0.018 (1.657)*	-0.004 (-7.898)***	0.004 (1.287)	-0.009 (-3.756)***
Building approval	0.000 (0.106)	0.000 (0.424)	-0.000 (-0.490)	0.001 (3.472)***	0.000 (0.934)	-0.000 (-2.125)**

Notes: This table only reports estimated volatility spillover coefficients (Eco_i) for "permanent" variance equations of C-GARCH (1,1) model. The model is estimated by
Mean Equation:

$$R_t = a_0 + a_1 R_{t-1} + a_2 R_{t-2} + a_3 R_{t-3} + a_4 Eco_{i,t-1} + \varepsilon_t$$

Variance Equations:

$$\sigma_t^2 - q_t = \alpha(\varepsilon_{t-1}^2 - q_{t-1}) + \beta\left(\sigma_{t-1}^2 - q_{t-1}\right)$$

$$q_t = \omega + \rho\left(q_{t-1} - \omega\right) + \phi\left(\varepsilon_{t-1}^2 - \sigma_{t-1}^2\right) + \gamma Eco_{i,t-1}$$

Bollerslev-Wooldrige robust standard error and covariance are employed. *, **, *** denotes significance at the 10%, 5% and 1% level respectively.

Table 9: "Transitory" Volatility Spillover

Cities	Australia	Sydney	Melbourne	Brisbane	Perth	Hobart
Real GDP	-0.001 (-0.391)	0.008 (2.578)***	-0.035 (-2.495)**	0.011 (3.745)***	0.008 (2.274)**	-0.003 (-0.820)
Income	0.000 (0.078)	0.010 (4.240)***	-0.019 (-3.333)***	0.004 (3.181)***	0.016 (1.484)	0.006 (1.083)
Population	0.090 (3.618)***	0.062 (1.239)	0.050 (2.460)**	0.045 (2.468)**	0.040 (2.986)***	-0.184 (-2.542)**
Unemployment	-0.000 (-0.566)	-0.000 (-1.947)*	0.000 (0.755)	0.000 (0.678)	-0.000 (-0.918)	-0.001 (-2.538)***
Lending rate	0.000 (1.922)*	0.001 (0.811)	0.001 (0.837)	0.001 (2.666)***	0.001 (4.018)***	0.001 (2.755)***
Inflation	0.011 (1.849)*	-0.009 (-4.633)***	0.022 (1.941)*	-0.004 (-2.745)***	-0.009 (-6.852)***	-0.003 (-0.935)
Building approval	0.000 (1.690)*	0.000 (1.486)	-0.000 (-0.285)	0.001 (12.305)***	-0.000 (-2.946)***	-0.000 (-1.657)*
Lagged Housing Prices	0.001 (2.576)***	0.001 (363.81)***	0.014 (3.469)***	0.006 (160.64)***	0.006 (3.430)***	0.004 (1.320)

Notes: This table only reports estimated volatility spillover coefficients (Eco_i) for "transitory" variance equations of C-GARCH (1,1) model. The model is estimated by

Mean Equation:

$$R_t = a_0 + a_1 R_{t-1} + a_2 R_{t-2} + a_3 R_{t-3} + a_4 Eco_{i,t-1} + \varepsilon_t$$

Variance Equations:

$$\sigma_t^2 - q_t = \alpha(\varepsilon_{t-1}^2 - q_{t-1}) + \beta\left(\sigma_{t-1}^2 - q_{t-1}\right) + \delta Eco_{i,t-1}$$

$$q_t = \omega + \rho\left(q_{t-1} - \omega\right) + \phi\left(\varepsilon_{t-1}^2 - \sigma_{t-1}^2\right)$$

Bollerslev-Wooldrige robust standard error and covariance are employed. *, **, *** denotes significance at the 10%, 5% and 1% level respectively.